

DERWENT-ACC-NO: 1995-241948
DERWENT-WEEK: 199641
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TITLE: Butt welding thermoplastics tube - employs special stepped geometry on the tube butt end faces

INVENTOR: USUI, S

PATENT-ASSIGNEE: KUREHA KAGAKU KOGYO KK[KURE], KUREHA CHEM IND CO LTD[KURE]

PRIORITY-DATA: 1993JP-0350096 (December 28, 1993)

PATENT-FAMILY:

| PUB-NO | PUB-DATE | LANGUAGE |
|---------------|-------------------|----------|
| PAGES | MAIN-IPC | |
| EP 662389 A3 | August 21, 1996 | N/A |
| 000 | B29C 065/14 | |
| EP 662389 A2 | July 12, 1995 | E |
| 009 | B29C 065/14 | |
| JP 07232379 A | September 5, 1995 | N/A |
| 006 | B29C 065/18 | |

CITED-DOCUMENTS: 2.Jnl.Ref; DE 3510552 ; DE 8612217 ; EP 264052 ; EP 546854 ; FR 1416625 ; FR 2012450 ; JP02106325 ; JP58199119 ; WO 8806966

APPLICATION-DATA:

| PUB-NO | APPL-DESCRIPTOR | APPL-NO |
|-------------------|-----------------|----------------|
| APPL-DATE | | |
| EP 662389A3 | N/A | 1994EP-0309840 |
| December 28, 1994 | | |
| EP 662389A2 | N/A | 1994EP-0309840 |
| December 28, 1994 | | |
| JP07232379A | N/A | 1994JP-0322899 |
| December 26, 1994 | | |

INT-CL (IPC): B29C065/14; B29C065/18 ; B29K101:12 ; B29L023:00

ABSTRACTED-PUB-NO: EP 662389A

BASIC-ABSTRACT: A method of butt welding tubular

thermoplastic objects such as pipes (12) involves a special geometry on the butt end (20). End face (20) is machined in the form of annular outer (22) and inner (24) coaxial portions united by a conical face (26). Inner portion (24) is recessed from outer portion (22) by a distance (D). The radial width of the recessed portion (t1) is a specified portion of pipe wall thickness (T). End faces (22, 24) are substantially perpendicular to the axis of pipe (12). Two pipes with like butt end geometrics are joined by known thermal fusion butt welding means.

ADVANTAGE - The butt end geometry results in a weld that is substantially free of any bead at the pipe bore.

CHOSEN-DRAWING: Dwg.2/5

TITLE-TERMS:

BUTT WELD THERMOPLASTICS TUBE EMPLOY SPECIAL STEP GEOMETRY
TUBE BUTT END FACE

DERWENT-CLASS: A35

CPI-CODES: A11-C01A; A12-H02;

ENHANCED-POLYMER-INDEXING:

Polymer Index [1.1]

017 ; H0317 ; S9999 S1661

Polymer Index [1.2]

017 ; ND07 ; N9999 N6166 ; Q9999 Q8731 Q8719 ; N9999
N6268*R ; N9999
N6202 N6177

SECONDARY-ACC-NO:

CPI Secondary Accession Numbers: C1995-110956

DERWENT-ACC-NO: 1989-123663
DERWENT-WEEK: 198917
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TITLE: Welding together thermoplastic pipes by thermally
irradiating - to fuse
both internally bevelled ends so that they are hotter at
outer dia. than inner
dia. and pressing them together

INVENTOR: KUNZ, P

PATENT-ASSIGNEE: FISCHER FA GEORG[FISG], FISCHER AG
GEORG[FISG]

PRIORITY-DATA: 1987CH-0003682 (September 23, 1987)

PATENT-FAMILY:

| PUB-NO | PUB-DATE | LANGUAGE |
|---------------|-------------------|----------|
| PAGES | MAIN-IPC | |
| EP 312712 A | April 26, 1989 | G |
| 003 | N/A | |
| CH 673433 A | March 15, 1990 | N/A |
| 000 | N/A | |
| DE 3863049 G | July 4, 1991 | N/A |
| 000 | N/A | |
| DK 166998 B | August 16, 1993 | N/A |
| 000 | B29C 065/18 | |
| DK 8805269 A | March 24, 1989 | N/A |
| 000 | N/A | |
| EP 312712 B | May 29, 1991 | N/A |
| 000 | N/A | |
| EP 312712 B2 | August 16, 1995 | G |
| 005 | B29C 065/18 | |
| ES 2022956 B | December 16, 1991 | N/A |
| 000 | N/A | |
| JP 01110128 A | April 26, 1989 | N/A |
| 000 | N/A | |
| JP 93072860 B | October 13, 1993 | N/A |
| 003 | B29C 065/18 | |

DESIGNATED-STATES: AT BE CH DE ES FR GB IT LI NL SE AT BE
CH DE ES FR GB IT LI N
L SE AT BE CH DE ES FR GB IT LI NL SE

CITED-DOCUMENTS: DE 1429001; DE 2157951 ; DE 2316500 ; US 3013925 ; EP 167870

APPLICATION-DATA:

| PUB-NO | APPL-DESCRIPTOR | APPL-NO |
|--------------------|-----------------|----------------|
| EP 312712A | N/A | 1988EP-0111586 |
| July 19, 1988 | | |
| DK 166998B | N/A | 1988DK-0005269 |
| September 22, 1988 | | |
| DK 166998B | N/A | DK 8805269 |
| N/A | | |
| EP 312712B2 | N/A | 1988EP-0111586 |
| July 19, 1988 | | |
| JP01110128A | N/A | 1988JP-0233824 |
| September 20, 1988 | | |
| JP93072860B | N/A | 1988JP-0233824 |
| September 20, 1988 | | |
| JP93072860B | Based on | JP 1110128 |
| N/A | | |

INT-CL (IPC): B29C065/18; B29L023/00 ; B29L023:00 ; F16L047/00

ABSTRACTED-PUB-NO: EP 312712A

BASIC-ABSTRACT: The ends of thermoplastic tubular components are welded together by heating them until they fuse and then pressing them together. They are heated by irradiation whereby the temp. produced drops down across from the o.d. to the i.d.; when they are joined together in a controlled manner there is little or no deformation produced on the i.d., the weld is efficiently made, and an optimal weld bead is formed on the o.d.

ADVANTAGE - The method largely eliminates the formation of a weld bead on the i.d.

ABSTRACTED-PUB-NO: EP 312712B

EQUIVALENT-ABSTRACTS: The ends of thermoplastic tubular components are welded together by heating them until they fuse and then pressing them together. They are heated by irradiation whereby the temp. produced drops

down across from the
o.d. to the i.d.; when they are joined together in a
controlled manner there
is little or no deformation produced on the i.d., the weld
is efficiently made,
and an optimal weld bead is formed on the o.d.

ADVANTAGE - The method largely eliminates the formation of
a weld bead on the
i.d.

CHOSEN-DRAWING: Dwg.0/4 Dwg.0/4

TITLE-TERMS:

WELD THERMOPLASTIC PIPE THERMAL IRRADIATE FUSE INTERNAL
BEVEL END SO HOT OUTER
DIAMETER INNER DIAMETER PRESS

DERWENT-CLASS: A35 Q67

CPI-CODES: A11-C01A; A12-H02;

POLYMER-MULTIPUNCH-CODES-AND-KEY-SERIALS:

Key Serials: 0229 3228 3241 2534 2667 2830

Multipunch Codes: 014 03- 454 489 52& 54& 602 604 608 674

SECONDARY-ACC-NO:

CPI Secondary Accession Numbers: C1989-054790

DERWENT-ACC-NO: 1988-285456
DERWENT-WEEK: 198840
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TITLE: Butt joining two thermoplastic tubes - by cutting
their respective ends
at an angle or a shape to fit together, heating to uniform
depth, and welding

INVENTOR: LUEGHAMER, A

PATENT-ASSIGNEE: GRUBER GMBH ALOIS [GRUBN], AGRU GRUBER &
SOHN [AGRUN]

PRIORITY-DATA: 1987DE-3708705 (March 18, 1987)

PATENT-FAMILY:

| PUB-NO | PUB-DATE | LANGUAGE |
|--------------|--------------------|----------|
| PAGES | MAIN-IPC | |
| WO 8806966 A | September 22, 1988 | G |
| 017 | N/A | |
| DE 3708705 A | October 6, 1988 | N/A |
| 000 | N/A | |
| DE 3867177 G | February 6, 1992 | N/A |
| 000 | N/A | |
| EP 305462 A | March 8, 1989 | G |
| 000 | N/A | |
| EP 305462 B | December 27, 1991 | N/A |
| 000 | N/A | |
| US 5188697 A | February 23, 1993 | N/A |
| 008 | B29C 065/20 | |

DESIGNATED-STATES: US AT BE CH DE FR GB IT LU NL SE AT BE
CH DE FR GB IT LI LU N
L SE AT BE CH DE FR GB IT LI LU NL SE

CITED-DOCUMENTS: DD 129758; DE 2830722 ; DE 2924930 ; DE
3510552 ; EP 167870
; FR 2012450 ; FR 2175779 ; FR 2382324 ; GB 1549169 ; GB
826526 ; NL 6903614
; US 3013925 ; US 3276941 ; US 3579826 ; US 4051218 ; US
4197149

APPLICATION-DATA:

| PUB-NO | APPL-DESCRIPTOR | APPL-NO |
|----------------|-----------------|----------------|
| WO 8806966A | N/A | 1988WO-EP00216 |
| March 17, 1988 | | |
| DE 3708705A | N/A | 1987DE-3708705 |
| March 18, 1987 | | |
| EP 305462A | N/A | 1988EP-0902472 |
| March 17, 1988 | | |
| US 5188697A | N/A | 1988WO-EP00216 |
| March 17, 1988 | | |
| US 5188697A | CIP of | 1989US-0283276 |
| April 21, 1989 | | |
| US 5188697A | N/A | 1989US-0789807 |
| April 21, 1989 | | |
| US 5188697A | Based on | WO 8806966 |
| N/A | | |

INT-CL (IPC): B29C065/20; B29C065/30 ; B29L023/22 ;
F16L047/02

ABSTRACTED-PUB-NO: WO 8806966A

BASIC-ABSTRACT: Plastic tubes, and particularly those of polyvinylidene fluoride, polypropylene or poly-ethylene, are bonded together by aligning together the ends of approx. equal dia. tubes, bringing them together, and welding them. The abutting faces concerned are undercut or attenuated on their i.d. so that their inner and outer edges are not in line; these faces are heat-softened to equal depth axially before being joined and welded together.

ADVANTAGE - The method and its equipment used virtually eliminates the formation of a weld bead on the i.d. of the joined tubes.

ABSTRACTED-PUB-NO: EP 305462B

EQUIVALENT-ABSTRACTS: Device for joining tubular parts (10,11) made from plastic, especially polyvinylidene fluoride, polypropylene or polyethylene, said parts (10,11) exhibit about the same diameter, with a heating element (20) for softening of the area of chamfered abutting surface (12,13) at least of one tubular part, characterised in that the contact

surface of heating
element (20) on abutting surface (12,13) of tubular part
(10,11) is designed to
correspond to undercut or recessed abutting surface
(12,13). (8pp)

US 5188697A

A device for joining tubular parts is made from plastics material. The device comprises a heating element for contacting and softening the end surfaces of parts to be joined. This element has a contact surface for contacting the tubes and corresp. to an undercut or recessed end surface to minimise the extent to which a bead of material is formed between the tubular parts after joining extends inward beyond their inner walls. A circular or disk-shaped lug is on the heating element and has a heating ring and an alignment disk both made from metal to locate a heat-resistant plastics ring between them as contact surface. ADVANTAGE - Welding beads are reduced.

CHOSEN-DRAWING: Dwg.0/5 Dwg.6/6

TITLE-TERMS:

BUTT JOIN TWO THERMOPLASTIC TUBE CUT RESPECTIVE END ANGLE
SHAPE FIT HEAT
UNIFORM DEPTH WELD

DERWENT-CLASS: A18 A35 Q67

CPI-CODES: A04-E10B; A04-G02E4; A04-G03E; A11-C01A;
A12-H02;

POLYMER-MULTIPUNCH-CODES-AND-KEY-SERIALS:

Key Serials: 0210 0223 0229 0239 0248 0843 2344 2359 2371
2454 3228 2458 3241
2534 2661 2751 0947

Multipunch Codes: 014 03- 041 046 047 050 062 064 071 371
376 387 454 455 489
52& 54& 575 597 602 674 688 726 014 062 064 087 371 376 623
629 688 723

SECONDARY-ACC-NO:

CPI Secondary Accession Numbers: C1988-126796
Non-CPI Secondary Accession Numbers: N1988-216953

DERWENT-ACC-NO: 1981-00122D
DERWENT-WEEK: 198101
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TITLE: Plastics profile butt welding - involves applying
recessed groove along
joints to absorb upsetting flash

PATENT-ASSIGNEE: BESLER A[BESLI]

PRIORITY-DATA: 1979DE-2923935 (June 13, 1979)

PATENT-FAMILY:

| PUB-NO | PUB-DATE | LANGUAGE |
|--------------|-------------------|----------|
| PAGES | MAIN-IPC | |
| DE 2923935 A | December 18, 1980 | N/A |
| 000 | N/A | |

INT-CL (IPC): B29C027/02

ABSTRACTED-PUB-NO: DE 2923935A

BASIC-ABSTRACT: Hollow plastic profiles are fabricated into
frame structures,
e.g. for doors and windows, by butt welding at the mitres.
An allowance must
be made for the upsetting length when the sections are cut
before the
application of heat and pressure to perform the butt joint.

All walls of the profiles which are visible when the frame
has been installed
are provided with a stepped recess along the proposed
joint. The dimensions of
the recesses are designed to compensate for the volume,
displaced by the
upsetting operation. The pref. method of producing the
recesses is milling in
one machining operation with the cutting operation.

TITLE-TERMS:

PLASTICS PROFILE BUTT WELD APPLY RECESS GROOVE JOINT ABSORB
UPSET FLASH

DERWENT-CLASS: A35 A93

CPI-CODES: A11-C01A; A12-R02;

POLYMER-MULTIPUNCH-CODES-AND-KEY-SERIALS:

Key Serials: 0229 2454 2458 2535 2692

Multipunch Codes: 011 03- 274 454 455 490 613 726



(12)

EUROPEAN PATENT APPLICATION

(21) Application number: **94309840.0**

(51) Int. Cl.⁶: **B29C 65/14, // B29L23:00**

(22) Date of filing: **28.12.94**

(30) Priority: **28.12.93 JP 350096/93**

(43) Date of publication of application:
12.07.95 Bulletin 95/28

(84) Designated Contracting States:
AT DE FR GB

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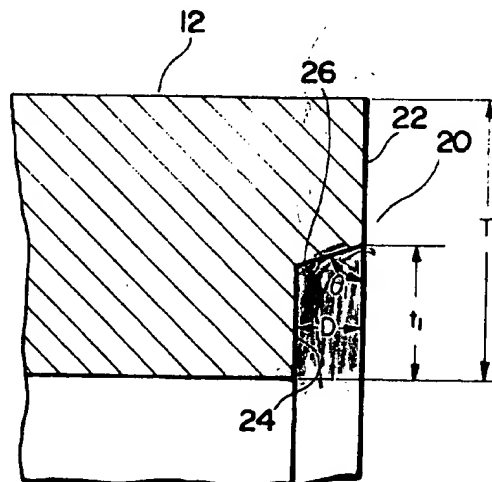
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(54) **Method for welding tubular members.**

(57) In the welding method of tubular members made of a thermoplastic synthetic resin, end faces to be welded, of a pair of tubular members are melted by heat of a heater, and the end faces are urged against each other to be welded. Prior to the melting of the end faces, each of the end faces is processed to a shape comprising a flat, annular, outer portion and a flat, annular, inner portion. The inner portion and outer portion both are perpendicular to the center axis of the tubular member, and the outer portion is set outside the inner portion along the center axis. Such a welding method can minimize the bead formed on the inner, circumferential surface and can achieve a high weld strength.

Fig. 2



The present invention relates to a butt welding method or butt fusion method, more particularly, a method for connecting a pair of tubular members made of a thermoplastic resin by heating end faces thereof and then pressing them together.

Tubular members made of a variety of synthetic resins are conventionally used in various applications. For example, tubular members formed of a general-purpose thermoplastic resin such as polyvinyl chloride, polypropylene, etc. are popularly used as distributing water pipes in houses or plants, etc., pipes for chemicals, etc. Further, tubular members made of a thermoplastic resin excellent in heat resistance and solvent resistance such as polyether ether ketone or polyphenylene sulfide, etc. are used as pipes for ultrapure water, in fabrication of electronic devices such as LSI, etc.

In actual piping using such tubular members of thermoplastic synthetic resins, it becomes necessary to connect a tubular member to another or to connect a tubular member to a tubular end of an instrument. One of the known connection methods between tubular members is a butt welding method or butt fusion method in which a heater heats to melt end faces of two tubular members to each other and thereafter the melted end faces are urged against each other to be connected thereby. This welding method can be classified into a contact type welding method in which end faces to be welded are melted in direct contact with the heater, and a non-contact type welding method in which end faces to be welded are melted not in contact with the heater with a gap between the heater and the end faces.

In the welding methods described above, the molten resin is pushed out radially inwardly and outwardly by the pressure upon welding, so that a projection called generally a "bead" is possibly formed on an inner circumferential surface or on an outer circumferential surface of the weld portion between the tubular members.

A bead formed on an inner circumferential surface of tube would cause a pressure loss of fluid flowing therein. Also, because a flow of fluid stagnates or is disturbed near the bead, microorganisms or fine particles could stay there. It is needless to mention that a pipe having a bead where microorganisms etc. could stay is not suitable particularly for use as a pipe for ultrapure water.

There is a method conventionally suggested, for example as disclosed in Japanese Laid-open Patent Application No. 64-71731, in which an expandable core is set inside the weld portion between the tubular members so as to fit on the inner circumferential surface thereof. This method, however, is not practically used in the welding method of the non-contact type because holding of the core is difficult.

Further, Japanese Laid-open Patent Applications No. 1-110128 and No. 2-106325 describe a method in

which inner edges of end faces to be welded are tapered so that when the end faces of tubular members are made to abut each other, cross sections thereof make a space of isosceles triangle, a so-called V-shape groove or bevel. When a pair of tubular members are pressed against each other to be joined, in the case of such a V-shape groove, the pressing force pushes out a molten resin in the weld portion, whereby the molten resin advances radially inward along the taper faces of the tubular members forming the groove so as to fill the groove. Accordingly, properly setting the size of the groove, the bead would be enough to fill the groove but not too much. Thus, an amount of projection from the inner surface of tube becomes smaller than in the case of no groove.

It is, however, difficult to form a groove of proper size. In actual use, when the welding is performed in such a manner that the molten resin or bead fully fills the groove, a relatively large bead projects from the inner circumferential surface of the pipe in spite of the formation of a groove. On the other hand, if the tubular members are pressed under a low pressure so as to reduce the projection amount of bead, the groove cannot be filled with the molten resin, resulting in forming a recess in the inner circumferential surface of pipe. Such a recess would become a place where microorganisms etc. stay. Also, this recess causes a notch effect. Specifically, when a stress is imposed on the pipe, the stress is concentrated on this recess so as to lower the mechanical strength of pipe, making the pipe undurable for practical use.

It is, therefore, an object of the invention to provide a welding method by which a size-limited bead is formed and a high weld strength can be attained.

To achieve the above object, the present invention is characterized by a welding method for tubular members in which end faces to be welded, of a pair of tubular members made of a thermoplastic resin are melted by heat of a heater, comprising a step of, prior to the melting of the end faces of the tubular members, processing each of the end faces into a shape comprising a flat, annular, inner portion which is normal to a center axis of the corresponding tubular member, and a flat, annular, outer portion arranged coaxially outside the inner portion, located at a position outside the inner portion along the center axis, and being normal to the center axis.

It should be noted that in the present invention the tubular members include tube connectors, profiles and nozzles, etc., and tubular portions of meters or devices such as valves as well as the pipes and tubes.

According to the welding method of the present invention as described above, there is almost no bead projecting from the inner circumferential surface of the weld portion of the pair of tubular members, and even if a bead is formed its size is very small.

The present invention will become more fully un-

d rsto d from the detailed description giv n h rein-
b low and the accompanying drawings which are giv-
en by way of illustration only, and thus are not to b
considered as limiting the pres nt invention.

Further scope of applicability of the present inven-
tion will become apparent from the detailed de-
scription given hereinafter. However, it should be un-
derstood that the detailed description and specific ex-
amples, while indicating preferred embodiments of
the invention, are given by way of illustration only,
since various changes and modifications within the
scope of the invention will become apparent to those
skilled in the art from this detailed description.

In the drawings:

Fig. 1 is a schematic, explanatory drawing to
show a non-contact-type welding apparatus
which is applicable to the welding method accord-
ing to the present invention;

Fig. 2 is a cross-sectional, partial drawing to
show an enlarged shape of an end face of a tub-
ular member processed according to an embodi-
ment of the present invention;

Fig. 3 is a cross-sectional, partial drawing to
show an enlarged shape of an end face of a tub-
ular member processed according to a second
embodiment of the present invention;

Fig. 4 is a cross-sectional, partial drawing to
show an enlarged shape of an end face of a tub-
ular member processed according to a third em-
bodiment of the present invention; and

Fig. 5 is a cross-sectional part to show an en-
larged shape of an end face of a tubular member
processed for comparison with the present inven-
tion.

The preferred embodiments of the present inven-
tion will be described in detail with reference to the ac-
companying drawings.

The welding method of tubular members accord-
ing to the following embodiments is of the so-called
non-contact type, and the tubular members applied
are formed by extrusion molding of a thermoplastic
synthetic resins, for example, fluororesins such as
perfluoroalkoxy resins polyether ether ketone, and
polyphenylene sulfide

Fig. 1 shows a welding apparatus 10 applicable
to the non-contact-type welding method according to
the present invention. This welding apparatus 10 is
well known, and is provided with clamps 14a, 14b for
holding a pair of tubular members 12a, 12b, respec-
tively, on a same axis. One clamp 14a is set on a base
16 of welding apparatus 10 so as to be movable to-
ward or away from the other clamp 14b. A heater 18
for heating to melt opposed end faces 20a, 20b of the
tubular members 12a, 12b is set between the clamps
14a, 14b, being arranged as capable of receding from
a movem nt path of the tubular memb r 12a. Th
h at r 18 is pref rably one consisting of a brass heat-
ing plate 19 and a rod heater (not shown) provided in

the h ating plat 19, but ther is no sp cific restric-
tion on the material for th heating plat 19. F r x-
ample, the material for the heating plate 19 may be a
metal sel cted from aluminum, brass, iron and cop-
per. The heating plate 19 may be subjected to a sur-
face treatment such as coating or surface finishing,
if necessary. Also, instead of the rod heater, the hea-
ter may be a nichrome wire etc. cast in the heating
plate 19.

For welding the pair of tubular members 12a, 12b
of a same shape using such a welding apparatus 10,
the tubular members 12a, 12b are first held by the
corresponding clamps 14a, 14b. By this, the tubular
members 12a, 12b are set on a same axis, and the
end faces 20a, 20b to be welded are set as opposed
to each other with a predetermined distance between
the end faces. Next, the heater 18 is disposed be-
tween the end faces 20a, 20b of tubular members
12a, 12b, and a current is supplied to the rod heater
in the heater 18. After heating for a predetermined
time, the heater 18 is moved to a receding position
and one movable clamp 14a is moved toward the
other clamp 14b. Then, the end faces 20a, 20b are
urged against each other under a predetermined
pressure for a predetermined time, thereby joining the
tubular members 12a, 12b.

The above is the method which has been per-
formed heretofore. Thus, if the end faces 20a, 20b of
tubular members 12a, 12b are not processed at all,
large beads are formed on the inner circumferential
surface and on the outer circumferential surface of
the tube. In the welding method according to the pres-
ent invention, the end faces 20a, 20b of tubular mem-
bers 12a, 12b are processed prior to the above weld-
ing step in order to remove or minimize the bead on
the inner circumferential surface of the tube.

Fig. 2 is a cross-sectional view to show an en-
larged shape of an end face to be welded, of one tub-
ular member. Here, the other tubular member is also
subjected to the same processing, but for simplicity
the description concerns only one tubular member.
As shown in Fig. 2, the end face 20 of tubular member
12 is stepped and is composed of an annular outer
portion 22 and an annular inner portion 24 arranged
coaxially and radially inside the outer portion 22. Each
of the outer portion 22 and inner portion 24 is substan-
tially a flat surface, which makes right angles with the
center axis of tubular member 12. Also, the outer por-
tion 22 projects outwardly from the inner portion 24
along the center axis with a predetermined distance
between them. Further, a boundary surface 26
formed between an inner circumferential edge of the
outer portion 22 and an outer circumferential edge of
the inn r portion 24 is a cylindrical surface or a con-
ical surface. This end face shape may be formed on
th fac 20 of tubular memb r 12 from the beginning
of molding, or may b formed in situ of welding by an
appropriat cutting or grinding apparatus.

Now, letting T be a wall thickness of the tubular member 12, more specifically a wall thickness of an end portion adjacent to the end face 20 to be welded, t_1 be a distance along the radial direction from the inner circumferential edge of the outer portion 22 to the inner circumferential surface of the tubular member 12, D be a distance along the direction of the axis between the outer portion 22 and the inner portion 24, and θ_1 be an angle between the face formed by the outer portion 22 and the generatrix or generant of the boundary surface 26, various experiments showed that the following conditions were preferably satisfied by the respective factors.

First, t_1 is normally set in the range of $0.1T \leq t_1 \leq 0.8T$, preferably in the range of $0.15T \leq t_1 \leq 7T$, more preferably in the range of $0.2T \leq t_1 \leq 0.6T$. If t_1 is smaller than $0.1T$, or if it is larger than $0.8T$, it is substantially the same as the non-processed end face 20. If welding is performed by the welding apparatus 10 under such a condition, i.e. $t_1 < 0.1T$ or $t_1 > 0.8T$, a large bead is formed on the inner circumferential surface of the tube.

The distance D is independent of the thickness T insofar as the welding conditions are not greatly affected by a change of thickness T of tubular member 12 to be welded. The distance D is normally set in the range of $0.1 \text{ mm} \leq D \leq 1.5 \text{ mm}$, preferably in the range of $0.2 \text{ mm} \leq D \leq 1.25 \text{ mm}$, more preferably in the range of $0.3 \text{ mm} \leq D \leq 1.0 \text{ mm}$. If D is smaller than 0.1 mm , there is no substantial difference from the non-processed end face 20, forming a large bead on the inner circumference of tube. On the other hand, if D is greater than 1.5 mm , the difference becomes unignorablely large between the distance from the heater 18 to the outer portion 22 of end face 20 and the distance from the heater 18 to the inner portion 24 of end face 20, whereby melting behavior greatly differs between the outer portion 22 and the inner portion 24, thus failing to obtain a desired strength after welding.

Also, θ_1 is normally set in the range of $45^\circ \leq \theta_1 \leq 90^\circ$, preferably in the range of $45^\circ \leq \theta_1 \leq 85^\circ$. If θ_1 is smaller than 45° , an area of the inner portion 24 decreases so as to form a large bead on the inner circumference of tube. If θ_1 is greater than 90° , an angle between the generatrix of the boundary surface 26 and the outer portion 22 becomes acute, so that the inner circumferential edge of the outer portion 22 comes to be located radially inward of the outer circumferential edge of the inner portion 24. Then, there would be cases where when the inner circumferential edge of the outer portion 22 is crushed upon welding, the boundary surface 26 covers the outer circumferential edge of the inner portion 24 so as to enclose air bubbles therein. Such bubbles negatively affect the weld strength.

After the end faces of the tubular members 12a, 12b to be welded are processed or machined so as to satisfy the above conditions, the tubular members

12a, 12b are welded using the welding apparatus 10 as described above, rarely forming a bead on the inner circumferential surface in the weld portion of tubular members 12a, 12b. Even if a bead is formed, the amount of projection thereof is very small. In the welding method of this embodiment, the inner portions 24 of end faces 20a, 20b which are in parallel with each other come to contact together, thus forming no recess on the inner circumferential surface in the weld portion, either.

The shape of the inner portion 24 of end face 20 is a flat surface in the above embodiment, but, as shown in Fig. 3, the inner circumferential edge of the inner portion 24 may be chamfered in a taper shape. Here, let t_2 be a distance along the radial direction from a border line between this taper face 28 and the other part (main part) of the inner portion 24 to the inner circumference of the tubular member 12, and θ_2 be an angle between a face formed by the other part of the inner portion 24 and the generatrix of the taper face 28. This distance t_2 is dependent on the distance t_1 as described above, and is set normally in the range of $0.05t_1 \leq t_2 \leq 0.5t_1$, preferably in the range of $0.1t_1 \leq t_2 \leq 0.4t_1$. Further, θ_2 is set normally in the range of $10^\circ \leq \theta_2 \leq 75^\circ$, preferably in the range of $20^\circ \leq \theta_2 \leq 60^\circ$, more preferably in the range of $30^\circ \leq \theta_2 \leq 45^\circ$. These are conditions which were obtained by experiments.

Moreover, as shown in Fig. 4, one or more, two in the shown embodiment, step faces 30, 32 may be formed by cutting or grinding in the portion adjacent to the inner circumferential edge of the inner portion 24 in the end face 20 of tubular member 12. The area of these step faces 30, 32 is determined as considerably smaller than the other portion of the inner portion 24. Also, these step faces 30, 32 are perpendicular to the center axis of tubular member 12. When such step faces 30, 32 are formed, the amount of projection of the bead also becomes very small.

Next described are results of experiments actually performed under the above conditions. First, polyphenylene sulfide pipes (25A manufactured by Kuraha Kagaku Kogyo: wall thickness 2.4 mm) were used as a pair of tubular members to be welded. End faces of the pipes were processed in the shape shown in Fig. 2. This time, the end faces were processed so that the above t_1 became 1.2 mm, D 0.3 mm, and θ_1 75° . Using the non-contact-type welding apparatus having the heater composed of the brass heating plate and rod heater, welding was carried out under such conditions that the surface temperature of the heating plate was 470°C , the distance from the end face of each pipe to the opposed heating plate 1 mm, the heating time 30 seconds, the press contact time 120 seconds, and the press contact pressure 600 kPa. As a result, a bead formed on the inner surface of the welded pipes was projected 0.5 mm from the inner circumference, having substantially a uniform

shape in the circumferential direction. Also, the weld strength obtained according to JIS K6776 was 60 MPa.

Further, another experiment was carried out under the same conditions except that end faces of polyphenylene sulfide pipes, which were the same as the above, were processed in the shape shown in Fig. 3. This time, t_1 was 1.2 mm, D 0.3 mm, θ_1 75°, t_2 0.6 mm, and θ_2 45°. In this case, no bead projecting from the inner circumferential surface of pipe was found, and the weld strength was 59 MPa.

Further, as a comparative example, end faces of polyphenylene sulfide pipes same as the above were processed in the shape shown in Fig. 5 so as to obtain a conventional V-shape groove, and the same experiment was conducted therewith. In this case, the angle θ_3 was 30°, and t_3 1 mm. In this experiment, the weld strength was 62 MPa which was satisfactory, but the amount of projection of a bead on the inner surface of pipe was great, 1.0 mm.

The above embodiments were illustrated to use the welding apparatus 10 as shown in Fig. 1, but the welding apparatus is not limited to the illustrated apparatus insofar as it can be applied to the non-contact-type welding method. For example, the heater comprising the heating plate as a heating method can be replaced by a heater of the infrared heating type. Also, the present invention can apply to the contact-type welding method.

As described above, if tubular members are welded according to the welding method of the present invention, weld strength durable for practical use can be attained and a bead is rarely formed on the inner circumferential surface of welded tubular members or if any, the size is very small. Accordingly, the present invention can solve or relieve the problems of pressure loss of fluid due to the bead and collection of microorganisms etc.

From the invention thus described, it will be obvious that the invention may be varied in many ways. Such variations are not to be regarded as a departure from the scope of the invention, and all such modifications as would be obvious to one skilled in the art are intended to be included within the scope of the following claims:

Claims

1. A welding method for tubular members in which end faces to be welded, of a pair of tubular members made of a thermoplastic resin are melted by heat of a heater and the end faces are urged against each other to be welded, comprising:
 - a step of, prior to melting said end faces of said tubular members, processing each of the end faces into a shape comprising a substantially flat, annular, inner portion which is normal to a

center axis of the corresponding tubular member, and a substantially flat, annular, outer portion arranged coaxially outside said inner portion, said outer portion being located at a position outside said inner portion along said center axis and being normal to said center axis.

2. A welding method according to Claim 1, wherein the condition of $0.1T \leq t_1 \leq 0.8T$ is satisfied where T is a wall thickness of an end portion of each of said tubular members adjacent to said end face and t_1 a distance along the radial direction between an inner circumferential edge of said outer portion and an inner circumferential surface of said end portion,

wherein the condition of $0.1 \text{ mm} \leq D \leq 1.5 \text{ mm}$ is satisfied where D is a distance along the center axis between said outer portion and said inner portion, and

wherein the condition of $45^\circ \leq \theta_1 \leq 90^\circ$ is satisfied where θ_1 is an angle between a generatrix of an annular boundary surface formed between the inner circumferential edge of said outer portion and an outer circumferential edge of said inner portion, and a face formed by said outer portion.

3. A welding method according to Claim 2, wherein the distance t_1 between the inner circumferential edge of said outer portion and the inner circumferential surface of said end portion satisfies the condition of $0.15T \leq t_1 \leq 0.7T$.

4. A welding method according to Claim 2, wherein the distance t_1 between the inner circumferential edge of said outer portion and the inner circumferential surface of said end portion satisfies the condition of $0.2T \leq t_1 \leq 0.6T$.

5. A welding method according to any one of Claims 2 to 4, wherein the distance D between said outer portion and said inner portion satisfies the condition of $0.2 \text{ mm} \leq D \leq 1.25 \text{ mm}$.

6. A welding method according to Claim 5, wherein the distance D between said outer portion and said inner portion satisfies the condition of $0.3 \text{ mm} \leq D \leq 1.0 \text{ mm}$.

7. A welding method according to any one of Claims 2 to 6, wherein the angle θ_1 between said generatrix of the boundary surface and the face formed by said outer portion satisfies the condition of $45^\circ \leq \theta_1 \leq 85^\circ$.

8. A welding method according to any one of the preceding claims comprising a step of chamfering an inner circumferential edge part of said inner portion.

tion in a taper shape.

9. A welding method according to Claim 8, wherein
the condition of $10^\circ \leq \theta_2 \leq 75^\circ$ is satisfied where
 θ_2 is an angle between a face of the taper shape
formed in said chamfering step, and a face
formed by said inner portion, and
wherein the condition of $0.05t_1 \leq t_2 \leq 0.5t_1$
is satisfied where t_1 is a distance along the radial
direction between an inner circumferential sur-
face of an end portion of each of said tubular
members adjacent to said end face, and an inner
circumferential edge of said outer portion, and t_2
a distance along the radial direction between an
outer circumferential edge of the face of said taper
shape and the inner circumferential surface
of said end portion.
10. A welding method according to Claim 9, wherein
the angle θ_2 between the face of said taper shape
and the face formed by said inner portion satisfies
the condition of $20^\circ \leq \theta_2 \leq 60^\circ$.
11. A welding method according to Claim 9, wherein
the angle θ_2 between the face of said taper shape
and the face formed by said inner portion satisfies
the condition of $30^\circ \leq \theta_2 \leq 45^\circ$.
12. A welding method according to Claim 9, wherein
the distance t_2 between the outer circumferential
edge of the face of said taper shape and the inner
circumferential surface of said end portion satisfies
the condition of $0.1t_1 \leq t_2 \leq 0.4t_1$.
13. A welding method according to any one of the pre-
ceding claims comprising a step of forming at
least one step face in a portion adjacent to an in-
ner circumferential edge of said inner portion.

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Fig. 1

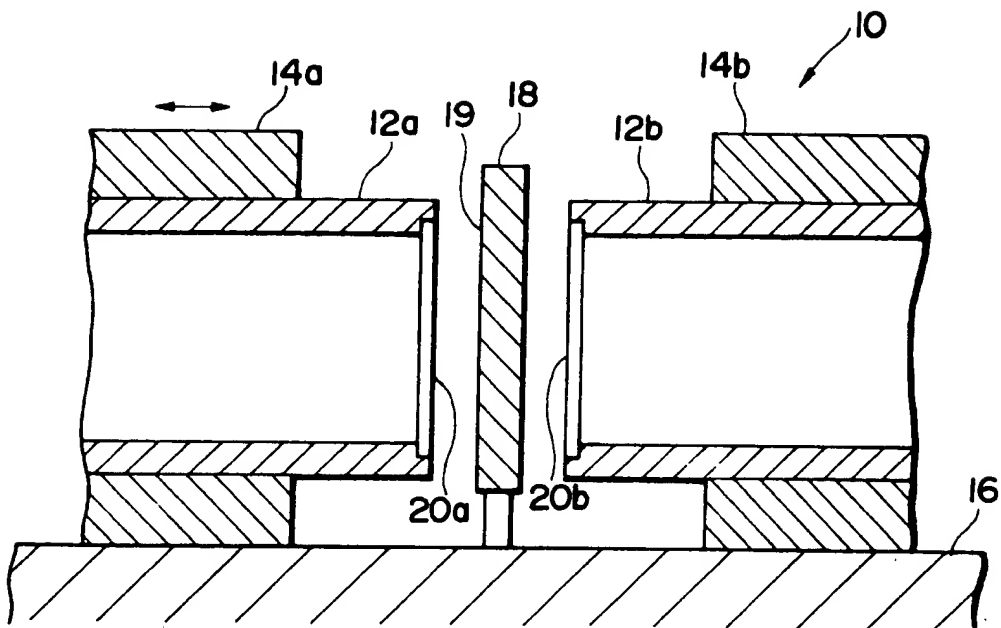


Fig. 2

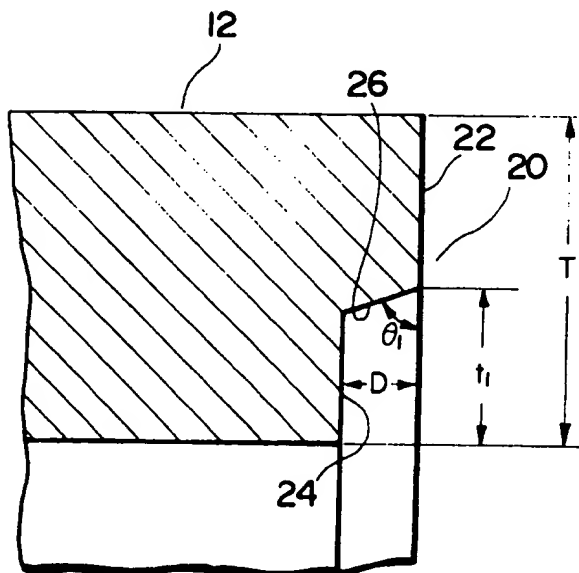


Fig. 3

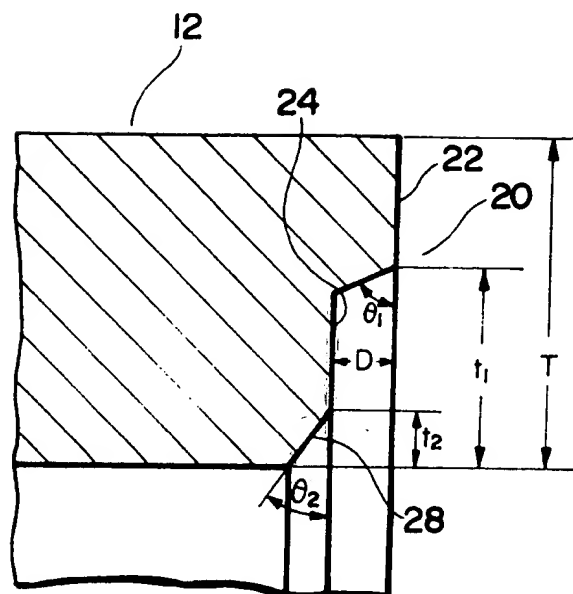


Fig. 4

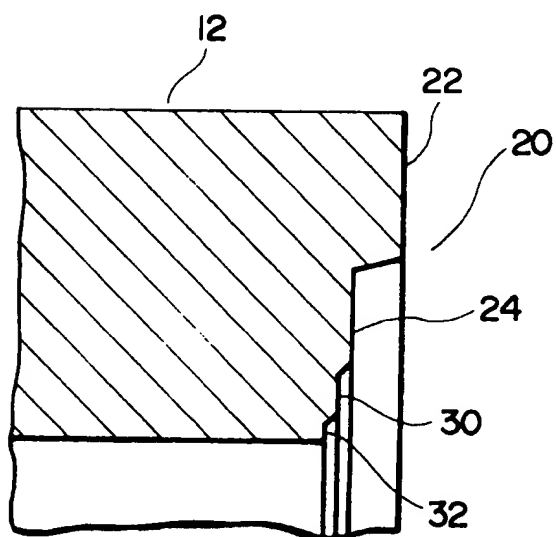
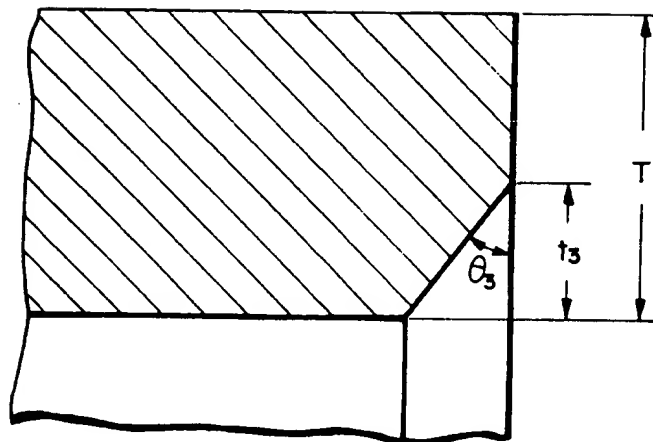


Fig. 5



(12) **EUROPEAN PATENT APPLICATION**

(88) Date of publication A3:
21.08.1996 Bulletin 1996/34

(51) Int Cl.⁶: **B29C 65/14**
// B29L23:00

(43) Date of publication A2:
12.07.1995 Bulletin 1995/28

(21) Application number: **94309840.0**

(22) Date of filing: **28.12.1994**

(84) Designated Contracting States:
AT DE FR GB

(30) Priority: **28.12.1993 JP 350096/93**

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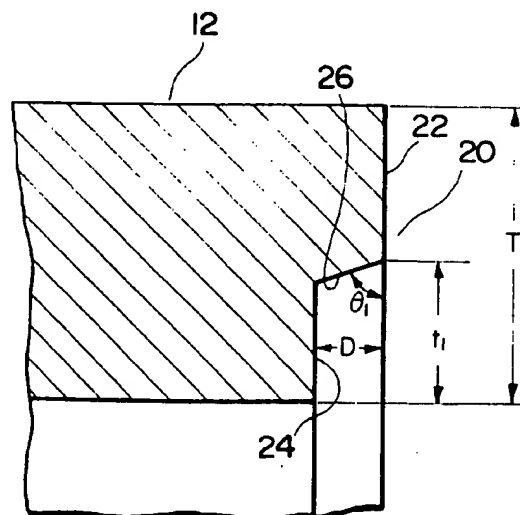
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(54) **Method for welding tubular members**

(57) In the welding method of tubular members made of a thermoplastic synthetic resin, end faces to be welded, of a pair of tubular members (12) are melted by heat of a heater (18), and the end faces are urged against each other to be welded. Prior to the melting of the end faces (20a, 20b), each of the end faces is processed to a shape comprising a flat, annular, outer por-

tion and a flat, annular, inner portion. The inner portion and outer portion both are perpendicular to the center axis of the tubular member, and the outer portion is set outside the inner portion along the center axis. Such a welding method can minimize the bead formed on the inner circumferential surface and can achieve a high weld strength.

Fig. 2





European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 94 30 9840

| DOCUMENTS CONSIDERED TO BE RELEVANT | | | |
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| Category | Citation of document with indication, where appropriate, of relevant passages | Relevant to claim | CLASSIFICATION OF THE APPLICATION (Int.Cl.6) |
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| X | EP-A-0 264 052 (URBAN GMBH CO MASCHBAU KG) 20 April 1988 * figure 1 * --- | 1-7 | |
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| A | DE-U-86 12 217 (HR PLASTIC-BERATUNGSBURO) 21 August 1986 * figure 4 * --- | 1-13 | |
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| | | -/-- | |
| The present search report has been drawn up for all claims | | | |
| Place of search THE HAGUE | | Date of completion of the search 28 June 1996 | Examiner Cordenier, J |
| <p>CATEGORY OF CITED DOCUMENTS</p> <p>X: particularly relevant if taken alone Y: particularly relevant if combined with another document of the same category A: technological background O: oral-written disclosure P: intermediate document</p> <p>T: theory or principle underlying the invention E: earlier patent document, but published on, or after the filing date D: document cited in the application L: document cited for other reasons &: member of the same patent family, corresponding document</p> | | | |

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EUROPEAN SEARCH REPORT

Application Number
EP 94 30 9840

| DOCUMENTS CONSIDERED TO BE RELEVANT | | | |
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| Category | Citation of document with indication, where appropriate, of relevant passages | Relevant to claim | CLASSIFICATION OF THE APPLICATION (Int.Cl.6) |
| A | DE-A-35 10 552 (VERLINDEN MARIUS A J) 25 September 1986 ----- | | |
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| | | | |
| The present search report has been drawn up for all claims | | | |
| Place of search THE HAGUE | | Date of completion of the search 28 June 1996 | Examiner Cordenier, J |
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